Environment and Natural Resources Trust Fund (ENRTF)
M.L. 2017 LCCMR Work Plan

Date of Submission: September 14, 2016

Date of Next Status Update Report: January 1, 2018

Date of Work Plan Approval:

Project Completion Date: June 30, 2020

Does this submission include an amendment request? No

PROJECT TITLE: Generation, Storage, and Utilization of Solar Energy

Project Manager: Bradley Heins

Organization: University of Minnesota

Mailing Address: 46352 State Hwy 329

City/State/Zip Code: Morris, MN 56267

Telephone Number: (320) 589-1711

Email Address: hein0106@umn.edu

Web Address: http://wcroc.cfans.umn.edu/research-programs/dairy

Location: Statewide

Total ENRTF Project Budget:		
	ENRTF Appropriation:	**$500,000**
	Amount Spent:	**$0**
	Balance:	**$500,000**

Legal Citation: M.L. 2017, Chp. xx, Sec. xx, Subd. xx

Appropriation Language:

I. PROJECT TITLE: Generation, Storage, and Utilization of Solar Energy

II. PROJECT STATEMENT:

Through past investments and institutional experience in renewable energy and dairy production research, the University of Minnesota West Central Research and Outreach Center (WCROC) has a globally unique opportunity to lead a new green revolution - a revolution that greens energy currently consumed within the agricultural industry. This proposal will leverage current efforts by further developing energy storage and utilization strategies for Minnesota. The agricultural industry consumes an immense amount of fossil-fuel in the production of food, feed, fiber, and energy. From the electricity that cools milk, to the fuel that is burned in combines and tractors in grain fields, to the trucks that bring goods to market, and to the nitrogen fertilizer that nourishes plants; the agricultural industry is captive to large and constant supplies of a wide range of fossil energy. Agriculture's dependence and thirst for fossil-fuel carries significant economic, environmental, and social risks for the nation and world. The overall objective of our project is to integrating solar technologies into dairy production systems to generate, store, and utilize electricity. The project team proposes to evaluate applicability and implementation of solar systems for shading of cattle, as well as generating electricity for charging systems that will be used to power electric vehicles from around western Minnesota. The team will leverage current research by testing clean energy charging systems and provide consumers with an evaluation of tested clean energy vehicles for livestock facilities and the highway system. Additionally, we will evaluate the cow cooling potential of solar systems in the grazing dairy system at the WCROC. The knowledge and information generated will be disseminated to agricultural producers, energy professionals, students, and other stakeholders through Extension websites, social media, and field days hosted at the WCROC.

Our general concept is to evaluate solar PV for multiple uses in a grazing-based dairy. In addition to generating electricity, the panels will be studied for use as livestock shade to improve animal comfort and productivity. The solar generated electricity will be utilized for a fast charging station. Electric all-terrain utility vehicles will be charged by solar energy and used within the pasture and dairy farm. An electric car will be charged with solar energy and used for travel to small and mid-sized commercial dairy farms to conduct baseline energy audits. This study is the first step to convert fossil-based vehicles used in dairy farms, to clean and locally produced energy.

III. OVERALL PROJECT STATUS UPDATES:

Project Status as of *January 1, 2018*:

Project Status as of *July 1, 2018*:

Project Status as of *January 1, 2019*:

Project Status as of *July 1, 2018*:

Project Status as of *January 1, 2020*:

Overall Project Outcomes and Results:

IV. PROJECT ACTIVITIES AND OUTCOMES:

ACTIVITY 1: Design solar systems and fast charging stations for dairy facilities.
Description:

A 30 kW ground-mounted solar photovoltaic system will be installed at the WCROC dairy pasture. Control systems will be installed and field tested. The control of farm-scale clean energy systems is deficient and a

barrier to adoption of clean energy systems. The solar PV system will be performance tested for one year for production and reliability. Once installed, production data from the 30 kW solar PV system will be measured and analyzed over a two-year time frame to determine gross and net energy production including diurnal and seasonal variation. The project team will direct an undergraduate student intern to assist in collecting data and evaluating the results. The student intern will develop a written report and provide a public presentation summarizing the results from the field test of the solar PV system.

Efforts will be made to standardize the design of the solar installation as it potentially may then be utilized for similar on-farm dairy facilities. The use of solar photovoltaic (PV) systems is a logical choice to performance test for the production of electrical energy for dairy facilities. In addition, new solar PV programs were put in statute during the 2013 Minnesota Legislative Session. Combined with the availability of federal USDA REAP grants and declining costs for solar PV, dairy producers may be able to cost effectively generate electricity to meet their load requirements. Solar PV also has peak production capacity during hot summer days which also matches high-energy load times for dairy facilities (ventilation).

We would also incorporate a fast charging system that would be able to charge the vehicles for travel and ATV for use in the dairy pasture system. We would incorporate the charger and the solar PV system. The fast charger would be part of the high-speed charging network in Minnesota, providing for electric vehicle usage in rural parts of Minnesota. The fast charger has 50 kW charging power and will fully charge an electric vehicle in 50 minutes.

We will assist to make electric vehicle ownership viable especially in rural Minnesota. We will field test electric vehicles at the WCROC. Two electric Polaris Ranger (or equivalent) will be utilized for daily agricultural uses in the dairy pasture production system at the WCROC. The Polaris Ranger (a Minnesota company produced vehicle) has an 30HP/48V AC electric motor, allowing for quite operation. The AC motor is more efficient and extends to range of use of the ATV. Performance records, charging records, and maintenance and usage records will be collected throughout the project for the ATV vehicles to demonstrate use in an agricultural application.

Furthermore, a 100% electric vehicle will be performance tested and utilized for travel to Minnesota dairy farm to collect energy usage data. All records pertaining to vehicle usage and maintenance will be logged for the 2 years of data collection on Minnesota dairy farms. The energy and charging systems, as well as electric vehicle use and demonstration will be tested for two years for production and reliability. This research will have much wider implications across agriculture and other industries.

Summary Budget Information for Activity 1:

ENRTF Budget: $ 254,750
Amount Spent: $ 0
Balance: $ 254,750

Outcome	Completion Date
1. Install a 30 kW photovoltaic solar system in a pasture at the WCROC dairy	7/1/2018
2. Install fast charging system to power clean energy vehicles	7/1/2018
3. Conduct field tests on electric vehicle charging with 100 % electric ATV and 100% electric vehicle at the WCROC	7/1/2018

Activity Status as of January 1, 2018:

Activity Status as of July 1, 2018:

Activity Status as of January 1, 2019:

Activity Status as of July 1, 2019:

Activity Status as of January 1, 2020:

Final Report Summary:

ACTIVITY 2: Evaluate the shade potential of solar systems for pastured-cattle
Description:
The team will utilize the solar production system in the pasture to effectively evaluate the cow-cooling and animal welfare benefits of using solar systems for shade potential at the WCROC. The Holstein and crossbred dairy cows at the WCROC will be divided into sub-herds balanced by parity, breed, and calving date, and assigned to two different shade treatments. The treatments will be shade with the solar PV system, or no-shade. Solar protection will be provided by the 30 kW PV structure in the pasture that will be mounted 7 to 8 feet off the ground. The lactating cows will be introduced to their respective treatments during the early portion of the grazing season (typically the end of May), and will be removed from pastures in the fall (typically in October). Throughout each summer, animals will be housed continuously in their respective settings on pasture, be milked twice a day, and be fed free-choice minerals on pasture.

Milk production will be quantified as daily milk weights and bi-weekly measures of fat, protein, SCC, and milk urea nitrogen while cows are under the solar PV shade structure compared to no shade. To evaluate animal health, cow body weights will be recorded monthly using a digital scale as cows exit the milking parlor, and all cows in each housing system will be visually scored for locomotion, body condition, hygiene, and hock lesions once monthly. Lameness will be scored using a 5-point locomotion scoring method, with 1 = normal locomotion to 5 = severely lame (Flower and Weary, 2006). Body condition scores will be 1 = excessively thin to 5 = excessively fat (Wildman et al., 1982). Locomotion and body condition scoring will be performed by a single observer as cows are exiting the milking parlor. Hygiene scores will be assessed by udder and lower hind leg cleanliness, with 1 = clean to 5 = dirty (Reneau et al., 2005). Hock lesions will be classified as 1 = no lesion, 2 = hair loss (mild lesion), and 3 = swollen hock with or without hair loss (severe lesion). Hygiene and hock lesion scoring will be done in the milking parlor before milking units are attached. To monitor mastitis, cows will be examined monthly for clinical mastitis and milk samples from mastitis cases will be collected, frozen, and later cultured for bacterial populations in accordance with the identification procedures recommended by the National Mastitis Council (NMC, 2004).

Lying behavior will be measured in all cows using data loggers once monthly for a period of 5 consecutive days. A behavior data logger (Hobo Pendant G Acceleration Data Logger, Onset Corporation, MA) will be placed on the rear lower leg of all cows during the same five consecutive days to record lying behavior, including lying time, and number and length of lying bouts. Additionally, both treatment groups will be observed for fly abundance and concurrent frequencies of defensive behaviors. Cows will be observed between 1:00 and 3:00 pm. Cows will be observed from a distance of 1 to 2 meters to allow for accurate fly counts without disturbing the cow's natural behaviors. An observer will approach an individual focal cow as available, then count and record the number of horn flies, stable flies, and face flies present on the animal. After counting flies, the focal cow will be observed for five minutes to tally defensive behaviors. A stopwatch will be used to keep track of time, and behaviors are tally marked on a data sheet. Behaviors recorded are head throws, front leg stamps, back leg stamps, skin twitches and tail flicks using definitions found in Mullens et al. (2006) and Dougherty et al. (1993): After five minutes, flies are counted again, and then pre- and post-observation counts are averaged to characterize abundance during the observation period. These processes are repeated until all cows are observed. Observations are compared with the next day's recorded milk production, presuming that any stress effects would be observed the following day.

Air temperature and relative humidity will be recorded automatically at 10-min intervals with environmental loggers (Hobo Pro Data loggers, Onset Computer Corp., Bourne, MA) for each day of the grazing season. Data loggers will be placed near the pastures, ensuring that they are always under the sun. Furthermore, data loggers will be placed under the shade structures directly under the solar PV shade on the northeast corner of the structure.

Dairy cattle behavior has been studied for years to identify factors that affect performance and health (Rutter et al., 1997). Grazing activities are sensitive to environmental variables such as pasture management and shade, and those factors in turn affect forage intake and behavior (forage selection, time spent grazing, pasture rate and consumption). We will assess grazing behavior in all cows with Heatime® HR Tags from SCR Dairy (SCR Engineers, Ltd., Netanya, Israel) around the neck of each cow in the study. This system allows us to track rumination (chewing) in addition to monitoring activity levels of cows. The monitors hold 24-hours of data and correspond with a long distance (LD) antenna placed atop the milking center. Unique to the HR Tag, we are also able to monitor rumination through a microphone installed around the neck. This microphone is actually picking up jaw movements as bones rub together during rumination. Rumination is measured in minutes per day. Additionally, behavior will also be assessed with the CowManager system (Agis Automatisering BV, Harmelen, The Netherlands). This system allows us to track feeding behavior, activity levels, rumination, and body temperature.

The project team will direct a Master's degree research assistant (graduate student) to assist in collecting data and evaluating the results that will become part of a Master's degree thesis.

Summary Budget Information for Activity 2:

ENRTF Budget: $ 81,250
Amount Spent: $ 0
Balance: $ 81,250

Outcome	Completion Date
1. Evaluate solar PV as a potential for shade for grazing dairy cattle in Minnesota	7/10/2019
2. Evaluate behavior of cattle with the use of the solar PV system	7/10/2019
3. Complete designs of clean energy systems for field testing at the WCROC	8/1/2019

Activity Status as of January 1, 2018:

Activity Status as of July 1, 2018:

Activity Status as of January 1, 2019:

Activity Status as of July 1, 2019:

Activity Status as of January 1, 2020:

Final Report Summary:

ACTIVITY 3: Field test dairy farm clean energy systems and develop effective control strategies
Description:
The team will utilize the dairy facilities at the WCROC to determine baseline energy use. Other on-farm clean energy systems will be monitored to determine production. A project team and graduate student will use the

information to recommend clean energy systems and rank them based on energy savings and / or return on investment.

The objective will provide actual energy consumption data for commercial dairy production systems. The data will be invaluable to our group and other researchers that seek to improve the energy efficiency of dairy production systems. We propose to monitor the energy consumption of operating, commercial dairy production systems for two years. Two years of monitoring is essential to understand influences of cow numbers, seasons, weather patterns, and milk production and harvesting on energy use in commercial systems.

We will identify commercial milk producers that operate dairy facilities that are characteristic of production systems in Minnesota. We will select 5 Minnesota dairy farms for farms for monitoring. The farms will include one small grazing based or tie-stall facility, 1 robotic dairy facility, and other mid-sized dairy farms that have developed a relationship with the UMN WCROC.

At each farm, we will record monthly the consumption of electricity, water usage, and fuel. Electric metering / sensing devices will be installed at each farm to record the total amount of electricity and water used by the farm, and for the milk harvesting procedures. Most farms use natural gas to heat their buildings so we will record the gallons of natural gas used each month. In addition, we will record monthly inventory of cows in the barns, cows milked per day, and milk production per day for the farm. Additionally, bulk tank production records (milk, fat percentage, protein percentage, and SCC), along with weekly cow numbers on farm will be collected from dairy farms. Daily milk production will be calculated as total bulk tank production divided by the average cow numbers on farm. In addition, we will collect monthly weather conditions from the NOAA weather observation site closest to each dairy farm that we are monitoring.

Based on the analysis of the data, a graduate student will model clean energy alternatives for Minnesota dairy facilities and. The student will utilize the baseline energy consumption data measured at the WCROC and on-farm dairy facilities to model energy-optimized retrofits. The project team will direct a graduate student and undergraduate student intern to project the economics for a suite of energy-optimized retrofits. Within the model, potentially all energy loads may be converted to electricity and these loads will be made as small as possible with efficiency upgrades. Eventually, on-site renewable electric generation could supply some or the entire electric load allowing the buildings to approach net-zero (producing as much energy as is used).

Summary Budget Information for Activity 3:

ENRTF Budget: $ 157,000
Amount Spent: $ 0
Balance: $ 157,000

Outcome	Completion Date
1. Install energy meters and record energy consumption data for 2 years at MN dairies	7/10/2019
2. Model clean energy alternatives with projected return-on-investment	7/10/2019
3. Complete designs of clean energy systems for field testing at the WCROC	8/1/2019

Activity Status as of January 1, 2018:

Activity Status as of July 1, 2018:

Activity Status as of January 1, 2019:

Activity Status as of July 1, 2019:

Activity Status as of January 1, 2020:

Final Report Summary:

ACTIVITY 4: Educate consumers, industry representatives, dairy producers and the general public about technology to generate, store, and utilize electricity from solar energy technologies

Description:
The most effective way to educate livestock producers and consumers to adopt new technologies is to demonstrate improved solar systems. The results from all activities will be used to demonstrate the potential of the electric charging systems. The research and outreach center will be used as the demonstration site to educate all of Minnesota about solar energy technologies.

We will develop a comprehensive extension program to educate producers, dairy professionals, and other stakeholders on the implementation of Solar PV, and electric vehicle testing in the pastures of WCROC, through the following activities: 1) Maintaining a web page within the University of Minnesota WCROC and Dairy Extension websites throughout the project and beyond dedicated to dissemination of electronic information, 2) Disseminate results and educational information via social media (Facebook and YouTube, and 3) Present study results at extension and professional conferences in the state and region. For all outreach activities, we will solicit feedback using standard survey documents, and these surveys will determine the impacts of our activities on audience knowledge and farmers' behaviors related to adopting practices that that will incorporate solar energy into Minnesota dairy farms.

Summary Budget Information for Activity 4:

ENRTF Budget: $ 7,000
Amount Spent: $ 0
Balance: $ 7,000

Outcome	Completion Date
1. Tour the Solar Shade PV system as a field stop for the WCROC Organic Dairy Day	12/30/2018
2. Host a tour and demonstration of the site and charging facility during our Midwest Farm Energy Conference at the WCROC.	5/30/2019
3. Conduct energy workshops and webinars across the State.	6/30/2020
4. Prepare Extension factsheets to inform stakeholders of the solar technologies.	6/30/2020

Activity Status as of January 1, 2018:

Activity Status as of July 1, 2018:

Activity Status as of January 1, 2019:

Activity Status as of July 1, 2019:

Activity Status as of January 1, 2020:

Final Report Summary:

V. DISSEMINATION:
Description:

The most effective way to educate and motivate livestock producers to adopt new technologies is to demonstrate improved profitability with the incorporation of solar energy into Minnesota dairy farms. The results from Activity 1 ,2, and 3 will be used to demonstrate the potential of the Solar PV system for Minnesota farms. The research and outreach center will be used as the demonstration site to showcase the opportunities for solar energy for farms, as well as generate new opportunities for the 5,000+ Minnesota dairy producers to utilize a solar energy to reduce the environmental footprint of their farm. These activities are well within the capabilities of the WRCOC and the University of Minnesota.

Status as of *January 1, 2018*:

Status as of *July 1, 2018*:

Status as of *January 1, 2019*:

Status as of *July 1, 2019*:

Status as of *January 1, 2020*:

Final Report Summary:

VI. PROJECT BUDGET SUMMARY:
A. Preliminary ENRTF Budget Overview:

Budget Category	$ Amount	Overview Explanation
Personnel:	$ 211,000	1 MS graduate student research assistant at 100% FTE in years 1 and 2; 1 junior scientist at 100% FTE for 2 years; and 1 undergraduate student intern for two years during summer term
Professional/Technical/Service Contracts:	$70,000	Up to 5 contracts with dairy producers for stipends to participate in baseline energy auditing study, 1 contract with a general contractor for the installation of the solar PV system and fast charger; and 1 contract with a mechanical contractor for installation of energy meters
Equipment/Tools/Supplies:	$63,500	Energy meters and data loggers for the dairy facilities. Fast charging system for electric vehicle charging and testing
Capital Expenditures over $5,000:	$130,000	30 kW solar PV system at the WCROC dairy pasture facilities; 2 Polaris or equivalent electric ATV for use at the WCROC pasture and for performance testing for Minnesota dairies
Travel Expenses in MN:	$20,000	Mileage, lodging, meals to regional conference and workshops; Lease of a 100% electric vehicle from the University of Minnesota for travel to Minnesota dairy farms participating in the study.

Other:	$5,500	Publication and regional workshop materials, and extension bulletins
TOTAL ENRTF BUDGET:	**$500,000**	

Explanation of Use of Classified Staff:

Explanation of Capital Expenditures Greater Than $5,000:
One solar photovoltaic system is being purchased and installed in the dairy pastures at the University of Minnesota West Central Research and Outreach Center. The system will be performance tested with results added to the models for optimizing commercial dairy facilities. In addition, 2 Polaris or equivalent elective ATVs will be purchased for performance testing and use at the WCROC for showcasing clean energy vehicles for farm use. Following the project, the WCROC will continue to use the equipment on similar projects for its expected serviceable life. If the equipment is sold prior to the end of its serviceable life, the proceeds will be paid back to the Environment and Natural Resources Trust Fund.

Total Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation: ~3.5 FTEs

Total Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation: 2

B. Other Funds:

Source of Funds	$ Amount Proposed	$ Amount Spent	Use of Other Funds
Non-state			
University of Minnesota (In-kind support)	$260,000	$0	The 52% foregone federally negotiated ICR funding constitutes the University of Minnesota cost share to the project.
State	0	0	
TOTAL OTHER FUNDS:	**$260,000**	**$0**	

VII. PROJECT STRATEGY:

A. Project Partners:

Dr. Bradley Heins, U of MN Dairy Scientist, will serve as PI and project manager. He will be responsible for all reports and deliverables. He will also manage the activities of the dairy production system at the research and outreach center, conduct solar studies, and manage the demonstration site. Michael Reese, U of MN WCROC Renewable Energy Director, and Dr. Lee Johnston, U of MN Swine Scientist, will be co-investigators managing the activities within their respected specialties. They will assist with outreach and dissemination of results. Eric Buchanan, WCROC Renewable Energy Scientist, will be the project coordinator assisting in the design, installation, testing, and control strategies of the solar charging technologies. He will also assist with the outreach and dissemination of results. AKF Engineering (Minneapolis) or equivalent will provide consulting services for clean energy modeling, designing, commissioning, and control strategies.

B. Project Impact and Long-term Strategy:

The WCROC has a 10-year strategic plan to reduce fossil energy consumption and the carbon footprint within dairy production systems. This collaborative project will build on renewable energy and solar technology activities of the project investigators. Previous funding has been received through the U of MN Initiative for Renewable Energy and the Environment and Xcel Energy RDF funds to measure energy consumption within the WCROC dairy and test clean thermal energy systems. This proposed project will facilitate and demonstrate the

need for energy charging systems in an agricultural setting. Additional long-term funding will be sought to conduct research with alternatives to fossil energy within all agricultural crop and livestock enterprises.

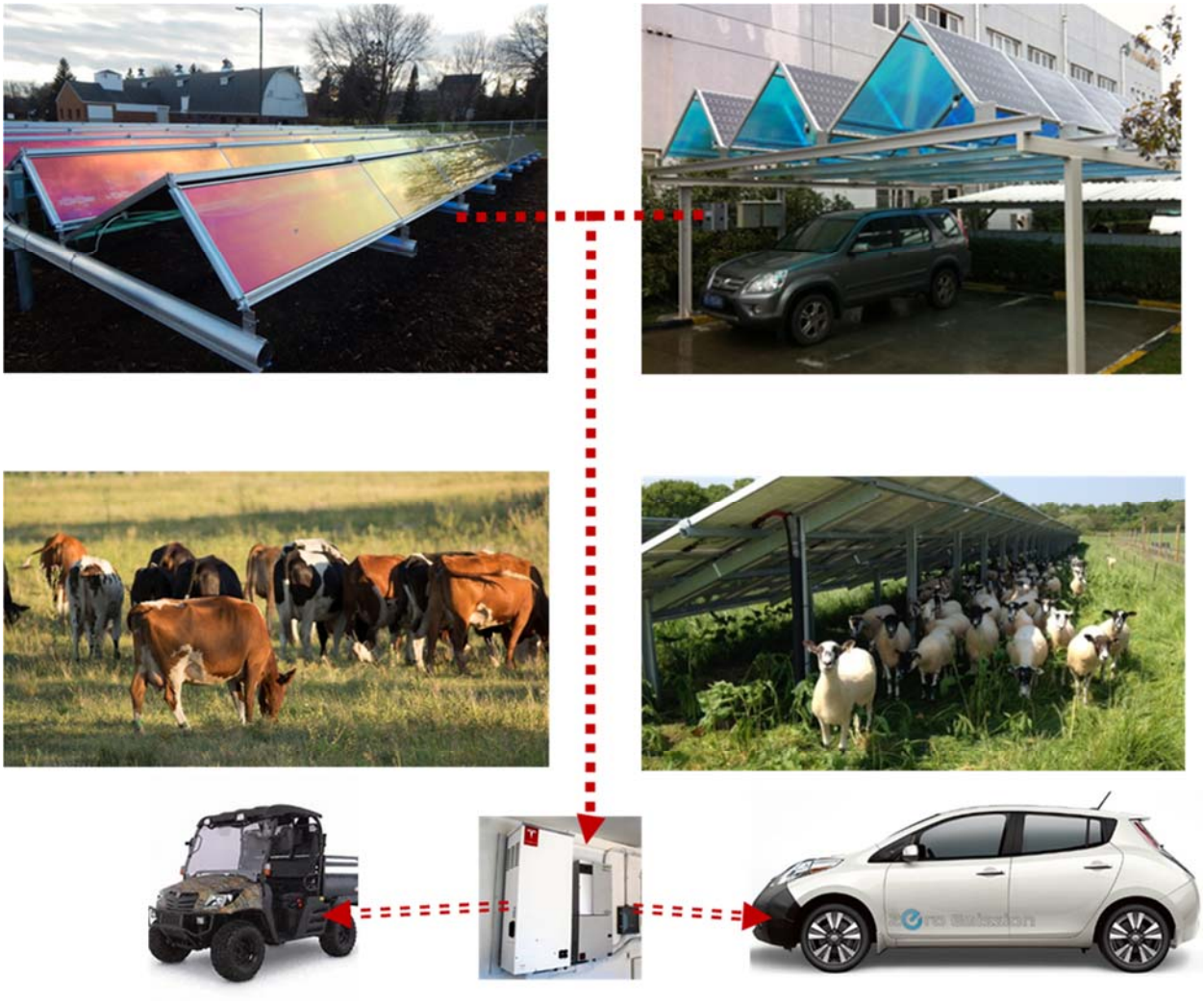
C. Funding History:

Funding Source and Use of Funds	Funding Timeframe	$ Amount
Funding was provided by the U of MN Initiative for Renewable Energy and the Environment (IREE) and the College of Food, Agricultural, and Natural Resource Sciences. The original IREE source of the funding was through Xcel Energy customers through MN Dept. of Commerce. Xcel Energy RDF has also provided funding for research at the WCROC dairy. This proposal leverages past and current work implementing clean energy technologies, life cycle, and economic analysis of energy-optimized crop and dairy production systems.		$1,350,000
2016 LCCMR Appropriation 148-E, Titled: Utilization of farm wastewater for sustainable dairy production		$475,000
		$1,825,000

VIII. REPORTING REQUIREMENTS:

- The project is for 3 years, will begin on July 1, 2017, and end on June 30, 2020.
- Periodic work plan status update reports will be submitted no later than January 1, 2018; July 1, 2018; January 1, 2019; July 1, 2019 and January 1, 2020. A final report and associated products will be submitted between June 30 and August 15, 2020.

IX. VISUAL COMPONENT or MAP(S):



X. FEE TITLE ACQUISITION/CONSERVATION EASEMENT/RESTORATION REQUIREMENTS: N/A

A. Parcel List: N/A

B. Acquisition/Restoration Information: N/A

Environment and Natural Resources Trust Fund

M.L. 2017 Project Budget

Project Title: Generation, Storage, and Utilization of Solar Energy

Legal Citation:

Project Manager: Bradley Heins

Organization: *University of Minnesota*

M.L. 2017 ENRTF Appropriation: $500,000

Project Length and Completion Date: *3 Years, June 30, 2020*

Date of Report: *September 14, 2016*

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Activity 1 Budget	Amount Spent	Activity 1 Balance	Activity 2 Budget	Amount Spent	Activity 2 Balance	Activity 3 Budget	Amount Spent	Activity 3 Balance	Activity =4 Budget	Amount Spent	Activity 4 Balance	TOTAL BUDGET	TOTAL BALANCE
BUDGET ITEM	***Design Solar System and charger***			***Evaluate Solar Shade potential***			***Field test dairy farm clean energy systems***			***Educate consumers and producers about solar***				
Personnel (Wages and Benefits)	$44,000		$44,000	$80,500		$80,500	$86,500		$86,500				$211,000	
Animal Science Graduate Research Assistant for 2 years; 17.60% fringe, plus tuition remission during the academic year and 17.60% fringe														
WCROC Junior Scientist for 2 years; Technician for data collection and testing; 100% FTE in Year 1 and 2, 33.7% fringe; estimated														
Undergraduate student intern - Solar Energy for Minnesota Dairy Farms (2 Yrs) 7.9 fringe; estimated $12, 000														
Professional/Technical/Service Contracts	$30,000		$30,000				$40,000		$40,000				$70,000	
Farmer Contracts -TBD - Monitoring of on-farm systems and supply of system specs							$35,000						$35,000	
General Contractor TBD - Installation of solar systems and charger	$30,000												$30,000	
Mechanical Contractor TBD - Installation of energy meters							$5,000						$5,000	
Equipment/Tools/Supplies	$50,000		$50,000				$13,500		$13,500	$3,000		$3,000	$66,500	
Energy Meters and Supplies for Dairy Facilities							$5,000						$5,000	
Data Loggers and Supplies for Dairy Facilities							$8,500						$8,500	
Electric vehicle fast charging system	$50,000												$50,000	
Costs include Extension programming, workshops, field days, factsheets, and dissemination of information at the WCROC										$3,000			$3,000	
Capital Expenditures Over $5,000	$130,000		$130,000										$130,000	
30 kW solar photovotaic (electric) system	$100,000												$100,000	
100% Electtic ATV (Polaris or equivalent) 48 Volt AC electic drivetrain, 2 units	$30,000												$30,000	
Travel expenses in Minnesota							$16,000		$16,000	$4,000		$4,000	$20,000	
Lease of University of Minnesota 100% electric vehicle. $600/month X 24 months; Will be utilized for traveling to dairy farms to collect							$15,000						$15,000	
Travel, Lodging and meals for WCROC project team at conferences and to dairy farms to collect data: Lodging and meals at two regional workshops (4 people / 2nights @90 room and $40 ea for meals); mileage for travel to							$1,000			$4,000			$5,000	
Other	$750		$750	$750		$750	$1,000		$1,000				$2,500	
Publication of research and demonstration in Open Access Journals - 3 publications	$750		$750	$750		$750	$1,000		$1,000				$2,500	
COLUMN TOTAL	**$254,750**	**$0**	**$254,750**	**$81,250**	**$0**	**$81,250**	**$157,000**	**$0**	**$157,000**	**$7,000**	**$0**	**$7,000**	**$500,000**	**$500,000**